RESPONSE OF PLANT GROWTH REGULATORS AND ORGANIC MANURE ON GROWTH, YIELD AND BIOCHEMICAL ATTRIBUTES IN DIFFERENT HYBRIDS OF CUCUMBER (*Cucumis sativus* L.) UNDER POLYHOUSE CONDITION

SYNOPSIS

Submitted to Eternal University

In the partial fulfillment for the

Degree of Ph.D. Horticulture (Vegetable Science)

By

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April, 2024

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1. **Title:** Response of plant growth regulators and organic manure on growth, yield and biochemical attributes of cucumber (*Cucumis sativus* L.) under polyhouse condition

2. **Introduction**: Cultivation of number of vegetables is due to the availability of various season and various climatic zones. The farmers harvest the crop early with higher yield and better quality of produce and get maximum returns out of it. Vegetable cultivation occupies an important place in Indian agriculture as they provide food, nutritional security and act as a source of income because they are giving higher return per unit area and time. Cucumber (*Cucumis sativus* L.*)* is commonly known as kheera, kakdi and sukasa. Among the cucurbits cucumber is cultivated on a maximum area due to its economical returns (Staub et al. 2008). The cucumber plant originated in India and was named Cucumis sativus var. hardwickii after a progenitor found in the Himalayan foothills of that country. It had spread eastwards to China and west words to Asia minor from India. Among the different vegetable crops cucumber ranks fourth in Asian continent. It is most important vegetable after tomato, onion and cabbage in Asia (Tatlioglu, 1997).

   Vegetables are an excellent source of vitamins, phytochemicals, dietary fibre, and minerals. It could be used for salad purpose, cooking, pickling, pahari rayata and commercially brined (Bairagi 2013). Cucumber has different health promoting properties along with antioxidant and mineral components which are essential for human diet. It is an astringent and antipyretic also helpful in maintaining the human blood alkalinity. The fruits are good for persons who are suffering from constipation, toothache and skin infection. Each 100g edible amount of cucumber includes 2.6g of carbohydrates, 0.6g of protein, 18 mg of calcium, 0.02 mg of thiamin, 12 calories of energy and 0.01 mg of niacin (Rashid 1999).

Protected cultivation is a new and emerging propensity for growing vegetables in India. Production of cucumber in India is mostly growing under field cultivation. It is also cultivated as a green house crop. Parthenocarpic cucumber is generally grown in polyhouse because pollination is not needed for its fruit setting. The cucumber is essentially a warm season, monoecious, annual, trailing or climbing vine which is primarily cultivated for its edible fruits. Cucumbers are a delicate, succulent fruit that can be eaten fresh or prepared with other vegetables. It reacts best in environments with high humidity, temperature and light intensity when there is a sufficient supply of water and nutrients..

Cucumber is cultivated all over the world the global area under its cultivation is 2.26 mha which resulted in production of 91.26 mt and productivity of 40.37t ha^{-1} (FAO, 2020). In India, the harvested area and production of cucumber is 0.11 mha and 1.59mt respectively with average productivity of 14.45t ha^{-1} (NHB, 2019). Hybrids react differently under the varied environmental conditions. Seedless cucumber is in demand these days so area and production is increasing manifold. In order to get higher production and productivity, selection of right combination of hybrids, PGR's and fertilizers should be used that would be increasing the income of farmers manifold.

PGR's application may result in increased sex expression towards female flowers thereby increasing the number of female flowers, number of fruits per vines along with fruit weight which resulted in increase yield parameters. Plant Growth Promoting Regulators (PGPR's) are organic compounds that modify the physiological processes of plant like plant growth, development, cell elongation and flower development (Ouzounidou et al. 2008). Plant hormones have been extensively studied for a long time due to their strong link with the regulation of growth and development in plants. They play in controlling the growth and elongation of plants, ion transport in plant cells, water uptake, transduction, activation of proteinase inhibitor genes, respiration, phloem unloading and gas exchange.

Triiodobenzoic Acid (TIBA) has been reported to influence flower formation of the cucumber, but little is known about its effect on fruit development. The influence of TIBA on auxin transport and other properties is analogous to that of 2-chloro-9-hydroxyfluorene-9-carboxylic acid (chlorflurenol), an extremely effective agent for inducing parthenocarpy in cucumber. In cucumbers, foliar PGR administration has been demonstrated to alter sex expression, yield, vegetative growth, and yield components, among other physiological and developmental processes. Triiodobenzoic Acid inhibited vegetative growth, suppressed flower growth and increase in formation of female flower in cucumber.

The most well-known was found in plant tissue extracts and animal cellular DNA (Barciszewski et al., 2000). Lower amounts of kinetin have beneficial effects on plants, but greater concentrations are harmful. It has been discovered that kinein contains oxygen, hydrogen, and carbon. Kinetin is a hormone that is required for plants and other living things. Numerous additional physiological and

developmental processes like floral development, leaf senescence, apical dominance, nutrient mobilisation, breaking of bud dormancy and seed germination, have also been demonstrated to be impacted by cytokinins.

According to Yang et al. (2019), brassinosteroids (BRs) may be a useful phytohormone to support phytoremediation. Plant species contain brassinosteroid in large quantities, which play a part in regulating the growth and development of plants. In order to increase plant growth and development, brassinosteroids are involved in metabolism; encourage cell division, cell elongation along with important physiological functions including photosynthesis and antioxidant system. According to Zicong Li and Yuehui He (2020), Brassinosteroids signalling facilitates etiolation and reproduction in addition to cell division and proliferation. Brassinosteroids help plants operate better during photosynthetic processes by maintaining a high level of chlorophyll content. Plant resistance to disease and other environmental stresses is improved as a result of it increasing due to the activity of protective enzymes and also assisting in the reduction of oxidative damage brought on by reactive oxygen species (ROS). They also enhance plants' ability to absorb water during drought conditions, preserve the integrity of the cell membrane, control biochemical and physiological processes within cells which raise crop output and quality.

Organic agriculture produces plants that are free from the toxic effects of chemicals (Redhaiman 2004). Searching for natural fertiliser substitutes that can boost soil nutrients, enhance its chemical and physical characteristics, and have minimal negative effects on the environment is one of the most significant contemporary developments that can boost vegetable crop yields and produce fertilizer-free products.

Organic amendments like biochar, farm yard manure and vermicompost has been shown to enhance plant and soil characteristics. Compost is an organic residue produced by earthworms during the aerobic and bio-oxidative breakdown of waste materials. It enhances soil structure, increases plant availability of nutrients, increases soil nutrient levels, and inhibits plant disease. Earthworms used different organic wastes (straw, sludge, livestock manure, etc.) as bait to create vermicompost, a naturally occurring biological organic fertiliser that is expelled after digestion (Guerrero 2010). It is abundant with microbes that can increase plants' resilience to illness by having antagonistic or inhibitory effects on a variety of pathogenic bacteria. (Benazzouk et al. 2020).

Biochar is solid i.e. insoluble, highly fragrant, stable and rich in carbon. It is created by slowly pyrolyzing biological leftovers at temperatures below 700°C in a hypoxic environment. (He et al. 2021). Because of its abundance of nutrient components, it not only improves the physicochemical qualities of soil by raising pH, porosity and water retention. Biochar decreasing bulk density and increases soil fertility and effectively restores deteriorated soil. Biochar can influence the diversity of

microbial communities by lowering the quantity of dangerous fungus in the soil, which can aid in halting the spread and development of dangerous plant diseases. (Zhang et al, 2021). Vermicompost and biochar are currently utilised extensively in agricultural production as significant organic amendments. It had demonstrated notable benefits in raising crop yield, improving soil fertility, and raising the calibre of agricultural output. (Tikoria et al., 2022).

Keeping these things in mind an experiment has been planned to know the Response of plant growth regulators and organic manure on growth, yield and biochemical attributes of cucumber (*Cucumis sativus* L.) under polyhouse condition.

Objectives: The expected outcome of this research will lead to the following points:

1. To find out best hybrid, fertigation dose and plant growth regulator giving maximum vegetative, quantitative and qualitative attributes.
2. To find out best interaction of hybrid × fertigation dose, plant growth regulator × fertigation dose and plant growth regulator × hybrid giving maximum vegetative, quantitative and qualitative attributes.
3. To find out the hybrid × fertigation dose × plant growth regulator giving maximum vegetative, quantitative and qualitative attributes.

3. Expected new knowledge

This study will provide valuable information regarding the selection of hybrid along with the concentration of plant growth regulators and organic manure that records maximum production along with better quality of cucumber (*Cucumis sativus*. L) under poly house condition, which will further help the farmers of Himachal Pradesh for enhancing their income and improve their livelihood.

4. Review of literature

4.1 Vegetative characters

Nadoda et al. (2023) conducted a study to know impact of growth regulators on the growth and flowering characteristics of cucumber (*Cucumis sativus* L.). The field experiment results demonstrated that GA_3 at 40ppm had a significant positive effect on minimum days required for the first male flower to appear and for the fruit to reach edible maturity. The application of Ethrel @300ppm resulted in a substantial increase female flowers and an elevated number of male flowers, thereby influencing the sex ratio.

Bajaj et al. (2022) was carried out to know the effect of different plant growth regulators on growth and phenological parameters of cucumber (*Cucumis sativus* L.) cv. Punjab Naveen. The

experimental trial was conducted in randomized block design with three replications. The experiment included eleven different treatments. The cucumber cultivar was planted at a spacing of 2.5m×0.6m during the experimental trial. The result revealed that maximum internodal distance was recorded by (5.11cm) GA_3 350ppm, minimum days taken to first flowering GA_3 100ppm (20.04), minimum days taken to 50% flowering at GA_3 100ppm (24.28), minimum number of male flowers per vine was recorded NAA @150ppm (19.39), minimum number of female flowers per vine at T_2 NAA @100ppm (12.66), T_3 NAA @150ppm (1:52:1).

Kusumiyati et al. (2022) to know the effect of different ethephon concentrations on vegetative, quantitative and qualitative attributes of three cucumber (*Cucumis sativus* L.) varieties. They employed three different ethephon concentrations in their investigation, which was reproduced three times. The cucumber varieties they tested were Vanesa, Mars, and Roberto. The results revealed that among different ethephon concentrations minimum day to flowering date and maximum number of female flower at 300ppm ethephon concentration.

Yadav et al. (2022). Conducted a study on Influence of Foliar Spray of Brassinosteroids, Salicylic Acid and Gibberellic Acid on Vegetative Growth and Flowering Parameters of Cucumber (*Cucumis sativus* L.) cv. Arpit. The study employed a Randomised Block Design replicated thrice with fifteen treatments. They employed the Sources of variables were the following: Brassinosteroids, Salicylic acid, Gibberellic acid as well as their combination with a control treatment administered as fifteen treatments were applied. Result revealed that the T_5 (Brassinosteroids @2.0ppm) showed the minimum days taken to first flower (36.66), bud initiation (35.73 days), number of male flower/ plant (91.71) and number of female flower per plant (47.59) in two years.

Dinesh et al. (2019) carried out a study to know the effect of different plant growth regulators on growth and flowering of cucumber cv. Malini under shade net conditions. They used ten treatments with three replications. GA_3 at 75ppm recorded maximum vine length (271.76cm), leaf area (458.14cm^2), number of leaves (90.32) and length of primary branches (153.25cm).

4.2 Quantitative characters

Afrillah et al. (2023) used liquid organic fertilizer on three cucumber varieties and check their response on growth and production of cucumber. The research was conducted in a factorial randomized block design with 2 treatment factors. They used 3 levels of coconut coir liquid organic fertilizer along with three types of varieties . The result revealed that the length of plant was highest in Mercy at 28 DAP (115.34), maximum stem diameter was obtained from hybrid Harmony on 28DAP (9.42), weight of fruit at harmony (347.22g), length of fruit Harmony (21.14cm).

Effa et al. (2023) used neem based biochar along with poultry manure and produce cucumber (*Cucumis sativus* L.) in humid tropical soil. They used four levels of poultry manure which were replicate three times. The study was conducted on randomized complete block design with eight treatment combinations. Maximum cucumber yields recorded by as compare to control plots.

Ahmad and Prasad (2022) used different organic manure in order to different organic manures on growth, yield and quality of cucumber (*Cucumis sativus* L.) c.v. Harsh under Prayagraj Agro Climate Condition. 10 treatment combinations were taken. Poultry manure 50% + vermicompost 50% recorded the maximum fruit length (18.34cm), number of fruits/plant (26.56), fruit yield/plant (6.12kg/plant), fruit yield/ hectare (15.90t/ha), fruit yield/plot (39.77kg) respectively.

Jandaghi et al. (2020) used different concentration in order to know some quantitative and qualitative parameters of seedling and mature greenhouse cucumber. They used four replications along with four treatment combinations. Results revealed that on raising the amount of chicken manure tea there is significantly increases shoot diameter (1.87cm), shoot length (28.08cm), true leaf length (1.67cm) and leaf width (16.45cm).

4.3 Qualitative characters

Kusumiyati et al. (2022) used different ethephon concentrations on three cucumber (*Cucumis sativus* L.) varieties in order to know the response of growth, yield and qualitative character. Treatments were replicated three times. The results revealed that maximum carotenoid content was recorded at 150ppm (130.58mg/g), maximum flavonoid content (139.53mg/g) was recorded at 300ppm, maximum phenolic content (414.84mg/g) at 150ppm.

Gokul et al. (2021) used different concentration of inorganic fertilizers, organic manures, biofertilizers and magnesium sulfate in order to know the effect of yield attributes, and quality of chilli. They used eleven treatments replicated three times. They used Randomized Block Design 75 per cent recommended dose of inorganic fertilizers + poultry manure @ 5 t ha-1+ biofertilizers + 2 per cent $MgSO_4$ recorded maximum ascorbic acid (351.11 mg/100g), total soluble solid (14.21 per cent), titrable acidity (0.13 per cent), total chlorophyll content (0.282 mg/g), and capsaicin content (0.74 per cent).

2021) carried out a study on different organic and inorganic fertilizer in order to know the growth, yield and quality traits of cucumber (*Cucumis sativus*) under Prayagraj Agroclimatic condition. Nine treatments, three replicates of each of the organic and inorganic fertilizer treatments were used in the Randomised Block Design experiment. The highest amount of vitamin C (8.39 mg) and total soluble solids (8.39 mg) were found in (Vermicompost + Sheep Manure + Neem Cake + NPK).

Thongney et al. (2018) studied effect of different levels of vermicompost and FYM organic manures on qualitative attributes of cucumber intercropped with citrus based agro forestry system at Prayagraj. Experiment consist of nine treatment combinations which were replicated three times. The results revealed that the maximum TSS (10°brix), vitamin C (8.39mg/100g) and acidity (0.90%) were found in the treatment combination that received 0% recommended doses of vermicompost, FYM and fertilizers.

3.4 Benefit: cost ratio

Dahal et al. (2022) carried out the study on cucumber with different application of plant growth regulators in the farmer field. They used five treatments with six replications under a walk-in plastic tunnel. The experiment was laid out in randomized complete block design. With NAA at 10 ppm, MH at 60 ppm, GA_3 at 50 ppm, and GA_3 at 100 ppm, the marketable fruit production was significantly higher than the control. The economic analysis revealed that application GA_3 @100ppm and GA_3 @50ppm recorded maximum B:C ratio (1.85) was observed at treatment NAA@10ppm.

Altaf et al. (2019) conducted an experiment to see the effect of NPK, organic manure and their combination on growth, yield and nutrient uptake of chilli (*Capsicum annuum* L.). The experiment used nine treatments, three replications, and randomised complete block design to apply NPK fertilisers along with organic manures. They stated that applying 100% NPK + 8t/ha of farmyard manure produced the maximum net return (at 30183 rupees per hectare).

Kadi et al. (2018) investigated different plant growth regulators on cucumber (*Cucumis sativus* L.) under polyhouse condition. They estimated that maximum gross returns and net returns were recorded by treatment at T_1 – GA_3 100ppm (85500Rs/ha), (41425Rs/ha) respectively whereas highest Benefit ratio 1:2.7 was recorded by NAA @ 50 ppm valued 1:2.7.

Kayesh et al. (2019) studied integrated nutrient management for growth, yield and profitability of broccoli. They found that maximum benefit cost ratio (3.64) was recorded in 25% recommended dose of fertilizer + polutry manure @ 12 t/ha.

Behera et al. (2020) carried out a research trial to know the combinations of nitrogen sources on yield, uptake, quality parameters and economics on chilli. Three replications and eight treatments were used in the Randomised Block Design. The result revealed that maximum B:C ratio was recorded 100% of N through recommended dose of fertilizer.

5. Technical programme

5.1 Title – Response of plant growth regulators and organic manure on growth, yield and biochemical attributes of cucumber (*Cucumis sativus* L.) under polyhouse conditions

5.2 Experimental Methodology-

i.	**Name of the crop**	-	Cucumber (*Cucumis sativus* L.)
ii.	**Location**	-	Research Station, Chhapang, Baru Sahib (H.P.)
iii.	**Plot size**	-	1.35m × 1.20m
iv.	**Spacing**	-	45cm × 30cm
v.	**Date of sowing-**		
•	**For 1st year**	-	March 2024
•	**For 2nd year**	-	Tentatively March 2025
vi.	**Date of transplanting-**		
•	**For 1st year**	-	Tentatively last week of March 2024
•	**For 2nd year**	-	Tentatively last week of March 2025
vii.	**Hybrid used**	-	4
•	**H_1**	-	Aviva
•	**H_2**	-	Adiva
•	**H_3**	-	Fadia
•	**H_4**	-	Afreen
viii.	**Number of treatment combinations**	-	64
ix.	**Replications**	-	3
x.	**Number of plots**	-	192
xi.	**Number of plants/plot**	-	8
xii.	**Design of the experiment**	-	Randomized Block Design (Factorial)
xiii.	**Fertilizer applied**	-	4
•	F_1	-	Control
•	F_2	-	Vermicompost (5t/ha)
•	F_3	-	Biochar (2.5t/ha)
•	F_4	-	FYM (25t/ha)
Plant Growth Regulator's applied		-	4
•	P_1	-	Control
•	P_2	-	Triiodobenzoic Acid (10ppm)
•	P_3	-	Kinetin (10ppm)
•	P_4	-	Brassinosteroids (2.0ppm)

5.3 Treatment Combinations

Treatment Combinations	Treatment details
$H_1F_1P_1$	Aviva (Control)
$H_1F_1P_2$	Aviva+Control+Triiodobenzoic Acid
$H_1F_1P_3$	Aviva+Control+Kinetin
$H_1F_1P_4$	Aviva+Control+Brassinosteroids
$H_2F_1P_1$	Adiva (Control)
$H_2F_1P_2$	Adiva+Control+Triiodobenzoic Acid
$H_2F_1P_3$	Adiva+Control+Kinetin
$H_2F_1P_4$	Adiva+Control+Brassinosteroids
$H_3F_1P_1$	Fadia+(Control)
$H_3F_1P_2$	Fadia+Control+Triiodobenzoic Acid
$H_3F_1P_3$	Fadia+Control+Kinetin
$H_3F_1P_4$	Fadia+ Control+Brassinosteroids
$H_4F_1P_1$	Afreen+(Control)
$H_4F_1P_2$	Afreen+Control+Triiodobenzoic Acid
$H_4F_1P_3$	Afreen+Control+Kinetin
$H_4F_1P_4$	Afreen+Control+Brassinosteroids
$H_1F_2P_1$	Aviva+Vermicompost+Control
$H_1F_2P_2$	Aviva+Vermicompost+Triiodobenzoic Acid
$H_1F_2P_3$	Aviva+Vermicompost+Kinetin
$H_1F_2P_4$	Aviva+Vermicompost+Brassinosteroids
$H_2F_2P_1$	Adiva+Vermicompost+Control
$H_2F_2P_2$	Adiva +Vermicompost+Triiodobenzoic Acid
$H_2F_2P_3$	Adiva+Vermicompost+Kinetin
$H_2F_2P_4$	Adiva+Vermicompost+Brassinosteroids
$H_3F_2P_1$	Fadia+Vermicompost+Control
$H_3F_2P_2$	Fadia+Vermicompost+Triiodobenzoic Acid
$H_3F_2P_3$	Fadia+Vermicompost+Kinetin
$H_3F_2P_4$	Fadia+Vermicompost+Brassinosteroids
$H_4F_2P_1$	Afreen+Vermicompost+Control
$H_4F_2P_2$	Afreen+Vermicompost+Triiodobenzoic Acid

$H_4F_2P_3$	Afreen+Vermicompost+ Kinetin
$H_4F_2P_4$	Afreen+Vermicompost+Brassinosteroids
$H_1F_3P_1$	Aviva+Biochar+Control
$H_1F_3P_2$	Aviva+Biochar+Triiodobenzoic Acid
$H_1F_3P_3$	Aviva+Biochar+Kinetin
$H_1F_3P_4$	Aviva+Biochar+Brassinosteroids
$H_2F_3P_1$	Adiva+Biochar+Control
$H_2F_3P_2$	Adiva+Biochar+Triiodobenzoic Acid
$H_2F_3P_3$	Adiva+Biochar+Kinetin
$H_2F_3P_4$	Adiva+Biochar+Brassinosteroids
$H_3F_3P_1$	Fadia+Biochar+Control
$H_3F_3P_2$	Fadia+Biochar+Triiodobenzoic Acid
$H_3F_3P_3$	Fadia+Biochar+ Kinetin
$H_3F_3P_4$	Fadia+Biochar+ Brassinosteroids
$H_4F_3P_1$	Afreen+Biochar+Control
$H_4F_3P_2$	Afreen+Biochar+Triiodobenzoic Acid
$H_4F_3P_3$	Afreen+Biochar+Kinetin
$H_4F_3P_4$	Afreen+Biochar+Brassinosteroids
$H_1F_4P_1$	Aviva+FYM+Control
$H_1F_4P_2$	Aviva+FYM+Triiodobenzoic Acid
$H_1F_4P_3$	Aviva+FYM+ Kinetin
$H_1F_4P_4$	Aviva+FYM+Brassinosteroids
$H_2F_4P_1$	Adiva +FYM+Control
$H_2F_4P_2$	Adiva+FYM+Triiodobenzoic Acid
$H_2F_4P_3$	Adiva+FYM+ Kinetin
$H_2F_4P_4$	Adiva+FYM+Brassinosteroids
$H_3F_4P_1$	Fadia+FYM+Control
$H_3F_4P_2$	Fadia +FYM+Triiodobenzoic Acid
$H_3F_4P_3$	Fadia +FYM+ Kinetin
$H_3F_4P_4$	Fadia+FYM+Brassinosteroids
$H_4F_4P_1$	Afreen+FYM+Control
$H_4F_4P_2$	Afreen+FYM+Triiodobenzoic Acid

$H_4F_4P_3$	Afreen+FYM+Kinetin
$H_4F_4P_4$	Afreen+FYM+Brassinosteroids

5.4 Observations to be recorded

5.4.1 Vegetative parameters

5.4.1.1 Days to Ist flowering (Days after sowing): It will be counted the number of days required by six tagged plant in each plot to reach flower initiation or anthesis of first flower after transplanting and then the average will be calculated.

5.4.1.2 Days to Ist female flowering (Days after sowing): The first female blooming date will be the date of transplantation till the first female flower appears in each of the five randomly chosen plants. The average of these dates will be computed to capture the data.

5.4.1.3 Internodal length (cm): Internodal length will be recorded by measuring the distance between any two nodes among the randomly selected plants by average will be worked out to determine the internodal length in cm.

5.4.1.4 Node of ^{1st} female flower (cm): The node of first female flower will be calculated from the base of plant till the node where the appearance of first female flowers in the five randomly selected plants and their mean value will be calculated and the data will be recorded.

5.4.1.5 Days of 1st picking (Days): The days to first picking will be counted from transplanting date till the 1st picking of fruits from all the randomly selected plants and their mean was calculated in order to record the calculated days of 1st picking.

5.4.1.6 Horizontal leaf width (cm): It will be calculated by measuring the horizontal leaf width of the leaf by means of scale from the randomly selected plants and their average value shall be calculated in order to record the data on horizontal leaf width.

5.4.1.7 Horizontal leaf length (cm): It will be calculated by measuring the horizontal leaf length of the leaf by means of scale from the randomly selected plants and their average value shall be calculated in order to record the data on horizontal leaf length.

5.4.2 Quantitative parameters

5.4.2.1 Number of Fruits/vine: The number of fruits which will be harvested from randomly selected vine at each harvest will be counted and finally all the fruits will be added in order to find out the number of fruits /vine.

5.4.2.2 Vine length (cm): The vine length will be calculated in cm from soil line till the tip of the vine during the final harvesting stage from the randomly selected plants and their mean values will be worked out to calculate the vine length.

5.4.2.3 Fruit weight (g): It will be calculated by weighing five fruits from randomly selected vines at each harvest and average will be calculated in each treatment. It will be expressed in (g).

5.4.2.4 Fruit diameter (mm): The fruit diameter of the fruit will be recorded treatment combinations, It will be measure using a digital vernier caliper. fruits were randomly selected from each plot and the average fruit diameter will be calculated in (mm).

5.4.2.5 Fruit Length (cm): Using a digital vernier caliper, the length of five randomly chosen fruits from each treatment combination will be measured. The average fruit length was computed in centimetres.

5.4.2.6 Number of leaves/vine: Number of leaves will be counted while uprooting the selected plants and it will be counted on day of final harvesting and finally their average will also be calculated.

5.4.2.7 Harvest duration: It was calculated by subtracting the days to 1st harvest from the days to final harvesting of cucumber fruit. The average of the selected plants from each treatment combination will be calculated in order to measure the total harvest duration.

5.4.2.8 Fruit yield/vine: The sum total of fruit weight of each tagged vine of each plot will be obtained from each picking and then the value will be pooled to work out the average yield per vine.

5.4.2.9 Fruit yield/plot: In each module yield from all plants in a plot from all the pickings will be calculated.

5.4.2.10 Fruit yield/ha (t/ha): Fruit yield/ha will be calculated from the fruit yield/m^2 from each plot. The value will be calculated in (t/ha).

5.4.3 Qualitative parameters

5.4.3.1 TSS (^{0}Brix): With the help of Digital Refractometer we will calculate the value of TSS from each tagged plant of each plot.

5.4.3.2 Titrable acidity (%): It will be determined by AOAC official method (AOAC, 2000).

$$\text{Titrable acidity} = \frac{V \times 0.1 \times 1000 \times 0.064}{m}$$

Where, 0.1- Normality of NaOH (N)

0.064- conversion factor for citric acid

V- Volume of NaOH required (ml)

M- Mass of tomato juice sample used (g)

5.4.3.3 Pericarp thickness (mm): The fruits will be cut transversely and the pericarp thickness is measured with the help of digital Verniercaliper.

5.4.3.4 Vitamin C (mg/100g): Titration using the Tillmans method.

5.4.3.5 Chlorophyll Content (mg/100g): Chlorophyll was extracted from leaves using dimethyl sulphoxide Hiscox and Israelstam (1979).

5.4.3.6 Carotenoid Content (mg/100g): The carotenoids will be calculated as per the method suggested by Ranganna (1995).The sample is extracted with acetone and then transferred to a separating funnel containing petroleum ether. Color absorbance at 452 nm is compared to a 3% acetone blank.

$$\mu g \text{ of carotene per } 100 \text{ gm} = \frac{\text{Conc. of carotene in solution x final volume x dilution}}{\text{Weight of sample}} \times 100$$

5.4.3.7 Phenolic Content (mg/100g): The total phenolic content will be determined by using the Folin-Ciocalteu reagent (Thimmaiah, 1999) and following a slightly modified method of (Ainsworth and Gillespie, 2007).

5.4.3.8 Mineral content: With the help of AOAC, 1990, method number 942.15 mineral content will be estimated. The samples will be digested H_2SO_4 (18.01mol/L), HNO_2 mixture (14.44mol/L) and $HClO_4$ (11.80mol/L), using AAS (Atomic Absorption Spectroscopy).

5.4.3.9 Shelf life (days): Shelf life of the cucumber will be determined by counting the number of days till the fruits will remain acceptable for marketing as suggested by Moneruzzaman et al. (2009).

5.4.3 Soil parameter

5.4.4.1 pH of soil: A pH meter will be used to measure the pH of the soil.

5.4.4.2 Electrical conductivity of soil (dS/m): It will be measured by using a device called an Ohmmeter. It measures the resistance of a substance to the flow of current.

5.4.4.3 Organic carbon (%): Organic carbon will be estimated with the help of titration method (Walkley and Black, 1934).

Organic carbon (%) in soil= $\frac{10(B-S)}{B} \times 0.003 \times \frac{100}{wt.of\ sample\ (g)}$

Where, B and S stand for the titre value (ml) of blank and sample, respectively.

5.4.5 Benefit: cost ratio- The following procedure was used to calculate the B.C. ratio for each module.

$$Net\ returns\ (Rs/ha) = \frac{Gross\ return - Cost\ of\ cultivation}{Cost\ of\ cultivation\ (Rs/ha)}$$

$$\text{B:C ratio} = \frac{Net\ return}{Cost\ of\ production}$$

5.5 Statistical analysis- Each replication's values for every observation were examined using a Randomized Block Design analysis. The following analysis of variance was recommended by Gomez & Gomez (1983)

Table no. 2 Analysis of variance

Source of variation	**Degree of freedom**	**Sum of square**	**Mean sum of square**	**F value**
Treatments	t-1	S_t	S_t / t-1	M_t/M_e
Replication	r-1	S_r	S_r/ r-1	M_r/M_e
Error (e)	(t-1) (r-1)	S_e	S_e / (t-1) (r-1)	M_e

Where: r = Number of replications

t = Number of treatments

Me = Error variance

We compared the F computed value and the F tabulated value. The standard error and critical difference will be estimated to assess if one therapy will be better than the other under each replication if the F test revealed a significant result.

The standard error and critical difference is calculated as:

$$SE(m) \pm = \sqrt{\frac{Me}{R}}$$

$$SE(d) \pm = \sqrt{\frac{2Me}{R}}$$

$CD_{0.05}$ (LSD) = SE (d) × t value at error degree of freedom

Where,

SE(m) ± = Standard error of mean

SE (d) ± = Standard error of difference

6. Collaboration (if any) (Nil)

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Signature of student